

## CLAIMS

### What is Claimed is:

1. A method of determining symbol timing in an input signal, comprising the steps of:
  - 5 computing a temporally varying magnitude of the input signal;
  - determining a frequency domain representation of the computed magnitude of the input signal;
  - identifying a spectral component at a symbol frequency  $f_s$  away from a DC component of the frequency domain representation of the computed magnitude of the input signal, the spectral component having a magnitude and a phase; and
  - 10 determining the symbol timing phase of the input signal from the phase of the spectral component.
2. The method of claim 1, wherein the step of determining a frequency  
15 domain representation of the computed magnitude of the input signal comprises the steps of:
  - performing a fast Fourier transform (FFT) of the computed magnitude of the input signal.
- 20 3. The method of claim 1, wherein the step of determining the symbol timing phase of the input signal from the phase of the spectral component comprises the steps of:
  - computing a temporal history of the symbol timing phase of the input signal and
  - computing the symbol timing phase of the input signal from the temporal history of the symbol timing phase of the input signal.

4. The method of claim 3, wherein the steps of computing a temporal history of the symbol timing phase of the input signal and computing the symbol timing phase of the input signal from the temporal history of the symbol timing phase of the input signal comprise the steps of:

5 determining a time domain representation of the frequency domain representation of the computed magnitude of the input signal in a window around the identified spectral component;

determining the symbol timing phase of the input signal from the time domain representation.

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5. The method of claim 4, wherein a width of the window is selected according to a jitter of the symbol timing in the input signal.

15 6. An apparatus for determining symbol timing in a input signal, comprising:  
means for computing a temporally varying magnitude of the input signal;  
means for determining a frequency domain representation of the computed  
magnitude of the input signal;

20 means for identifying a spectral component at a symbol frequency  $f_s$  away from a  
DC component of the frequency domain representation of the computed magnitude of the  
input signal, the spectral component having a magnitude and a phase; and

means for determining the symbol timing phase of the input signal from the phase  
of the spectral component.

7. The apparatus of claim 6, wherein the means for determining a frequency domain representation of the computed magnitude of the input signal comprises:

means for performing a fast Fourier transform (FFT) of the computed magnitude of the input signal.

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8. The apparatus of claim 6, wherein the means for determining the symbol timing phase of the input signal from the phase of the spectral component comprises:

means for computing a temporal history of the symbol timing phase of the input signal and computing the symbol timing phase of the input signal from the temporal

10 history of the symbol timing phase of the input signal.

9. The apparatus of claim 8, wherein the means for computing a temporal history of the symbol timing phase of the input signal and computing the symbol timing phase of the input signal from the temporal history of the symbol timing phase of the input signal comprises:

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means for determining a further frequency domain representation of the frequency domain representation of the computed magnitude of the input signal in a window around the identified spectral component;

20 means for determining the symbol timing phase of the input signal from the further frequency domain representation.

10. The apparatus of claim 9, wherein the symbol timing phase is determined as a DC component of the further frequency domain representation.

25 11. The apparatus of claim 9, wherein a width of the window is selected according to a jitter of the symbol timing in the input signal.

12. An apparatus for determining symbol timing in a input signal, comprising:  
a first processor module for computing a temporally varying magnitude of the  
input signal;

5 a Fourier transform module for determining a frequency domain representation of  
the computed magnitude of the input signal;

second processor module for identifying a spectral component at a symbol  
frequency  $f_s$  away from a DC component of the frequency domain representation of the  
computed magnitude of the input signal, the spectral component having a magnitude and  
a phase; and

10 a third processor module for determining the symbol timing phase of the input  
signal from the phase of the spectral component.

13. The apparatus of claim 12, wherein Fourier transform module is a fast  
Fourier transform (FFT) module.

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14. The apparatus of claim 12, wherein the third processor module computes a  
temporal history of the symbol timing phase of the input signal and computes the symbol  
timing phase of the input signal from the temporal history of the symbol timing phase of  
the input signal.

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15. The apparatus of claim 14, wherein the processor computes a temporal  
history of the symbol timing phase of the input signal and computes the symbol timing  
phase of the input signal from the temporal history of the symbol timing phase of the  
input signal by determining a further frequency domain representation of the frequency  
25 domain representation of the computed magnitude of the input signal in a window around  
the identified spectral component, and determining the symbol timing phase of the input  
signal from the further frequency domain representation.

16. The apparatus of claim 15, wherein the symbol timing phase is determined  
30 as a DC component of the further frequency domain representation.

17. The apparatus of claim 15, wherein a width of the window is selected according to a jitter of the symbol timing in the input signal.

5 18. A method of acquiring a carrier frequency in a input signal, comprising the steps of:

computing an  $N^{th}$  power of the input signal;

determining a frequency domain representation of the computed  $N^{th}$  power of the input signal, the frequency domain representation including spectral components spaced

10 at  $\frac{f_s}{N}$ , wherein  $f_s$  is a symbol frequency of the input signal; and

selecting one of the spectral components as the acquired carrier frequency.

19. The method of claim 18, wherein the step of determining a frequency domain representation of the computed  $N^{th}$  power of the input signal comprises the step  
15 of computing a fast Fourier transform (FFT) of the computed  $N^{th}$  power of the input signal.

20. The method of claim 18, wherein the input signal comprises a series of symbols selected from a set of  $N$  symbols.

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21. The method of claim 18, wherein the frequency domain representation includes  $i$  spectral components, and wherein the step of selecting one of the spectral components as the carrier frequency comprises the steps of:

25 determining an energy  $\{P_i\}$  of the input signal in a window centered at a frequency of each of the spectral components; and

determining the frequency of the spectral component associated with the largest of the  $i$  determined energies  $\{P_i\}$  as the acquired carrier frequency.

22. The method of claim 18, further comprising the step of determining the carrier phase as the phase of the selected one of the spectral components.

23. The method of claim 22, wherein step of determining the carrier phase of the input as the phase of the selected one of the spectral components comprises the steps of:

computing a temporal history of the carrier phase of the input signal and computing the carrier phase of the input signal from the temporal history of the carrier phase of the input signal.

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24. The method of claim 23, wherein the steps of computing a temporal history of the carrier phase of the input signal and computing the carrier phase of the input signal from the temporal history of the carrier phase of the input signal comprises the steps of:

15 determining a time domain representation of the determined frequency domain representation of the computed  $N^{th}$  power of the input signal in a window around the selected one of the spectral components; and

determining the carrier phase of the input signal from the time domain representation.

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25. An apparatus for acquiring a carrier frequency in a input signal, comprising:

means for computing an  $N^{th}$  power of the input signal;

25 means for determining a frequency domain representation of the computed  $N^{th}$  power of the input signal, the frequency domain representation including spectral components spaced at  $\frac{f_s}{N}$ , wherein  $f_s$  is a symbol frequency of the input signal; and

means for selecting one of the spectral components as the acquired carrier frequency.

26. The apparatus of claim 25, wherein the means for determining a frequency domain representation of the computed  $N^{th}$  power of the input signal comprises means for computing a fast Fourier transform (FFT) of the computed  $N^{th}$  power of the input signal.

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27. The apparatus of claim 25, wherein the input signal comprises a series of symbols selected from a set of  $N$  symbols.

28. The apparatus of claim 25, wherein the frequency domain representation includes  $i$  spectral components, and wherein the means for selecting one of the spectral components as the carrier frequency comprises:

means for determining an energy  $\{P_i\}$  of the input signal in a window centered at a frequency of each of the spectral components; and  
means for determining the frequency of the spectral component associated with the largest of the  $i$  determined energies  $\{P_i\}$  as the acquired carrier frequency.

29. The apparatus of claim 25, further comprising means for determining the carrier phase as the phase of the selected one of the spectral components.

30. The apparatus of claim 29, wherein means for determining the carrier phase of the input as the phase of the selected one of the spectral components comprises:  
means for computing a temporal history of the carrier phase of the input signal and computing the carrier phase of the input signal from the temporal history of the carrier phase of the input signal.

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31. The apparatus of claim 30, wherein the means for computing a temporal history of the carrier phase of the input signal and computing the carrier phase of the input signal from the temporal history of the carrier phase of the input signal comprises:

- means for determining a further frequency domain representation of the
- 5 determined frequency domain representation of the computed  $N^{th}$  power of the input signal in a window around the selected one of the spectral components; and
- means for determining the carrier phase of the input signal from the further frequency domain representation.

10 32. An apparatus for acquiring a carrier frequency in a input signal, comprising:

- a first processor module for computing an  $N^{th}$  power of the input signal;
- a Fourier transform module for determining a frequency domain representation of the computed  $N^{th}$  power of the input signal, the frequency domain representation
- 15 including spectral components spaced at  $\frac{f_s}{N}$ , wherein  $f_s$  is a symbol frequency of the input signal; and
- a second processor module means for selecting one of the spectral components as the acquired carrier frequency.

20 33. The apparatus of claim 32, wherein the Fourier transform module is a fast Fourier transform (FFT) module.

34. The apparatus of claim 32, wherein the input signal comprises a series of symbols selected from a set of  $N$  symbols.



35. The apparatus of claim 32, wherein the frequency domain representation includes  $i$  spectral components, the second processor selects one of the spectral components as the acquired carrier frequency by determining an energy  $\{P_i\}$  of the input signal in a window centered at a frequency of each of the spectral components, and selects  
5 the frequency of the spectral component associated with the largest of the  $i$  determined energies  $\{P_i\}$  as the acquired carrier frequency.

36. The apparatus of claim 32, further comprising a third processor module for determining the carrier phase as the phase of the selected one of the spectral components.  
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37. The apparatus of claim 36, wherein the third processor module determines the carrier phase of the input as the phase of the selected one of the spectral components by computing a temporal history of the carrier phase of the input signal and computing the carrier phase of the input signal from the temporal history of the carrier phase of the  
15 input signal.